CLIMATE CHANGE AND AIR QUALITY

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Climate and air quality are closely coupled. As discussed in previous sections of this report, conventional pollutants, such as ozone and particle pollution, not only affect public health but also contribute to climate change. Ozone is a significant greenhouse gas (GHG) and particles can influence the climate by scattering, reflecting, and/or absorbing incoming solar radiation and interacting with various cloud processes (see Ozone and Particle Pollution sections). Climate and meteorology directly influence ambient concentrations of particles and ozone, in part by affecting emissions of precursors from natural sources such as plants and trees. Thus, though climate and air quality are often treated as separate issues, there are important interactions that need to be considered and addressed.

Ozone and black carbon (BC) both affect public health and climate. Their impacts differ from those of long-lived GHGs because ozone and particle pollution generally stay in the atmosphere for only a few days or weeks. Therefore, these short-lived pollutants may not travel as far and tend to be unevenly distributed in the atmosphere. Long-lived GHGs like carbon dioxide (CO_2) persist in the atmosphere over decades to centuries and eventually become fairly evenly distributed throughout the Earth's atmosphere. Because they persist, long-lived GHGs will continue to exert influence over climate, meteorology, and air pollution levels far into the future.

Because ozone and BC have short atmospheric lifetimes, reducing these emissions has a strong, immediate climate benefit. While controlling long-lived GHGs is essential for addressing climate effects in the long term, controlling short-lived climate pollutants may be a good strategy to reduce the rate of climate change in the near-term. Reducing short-lived climate pollutants can supplement programs to reduce the long-lived climate pollutants.

Given the links between climate and air quality, the National Academy of Sciences (NAS) recommended in its 2004 report, *Air Quality Management in the United States,* that air pollution and climate change policies be developed through an integrated approach. A number of strategies being discussed for climate—energy efficiency, renewable energy, and reducing the number of vehicle miles traveled—will provide reductions in emissions that contribute to multiple air quality concerns such as ozone and particle pollution, toxic air pollutants, atmospheric deposition, and visibility. These kinds of approaches are "win-win,"providing improvements to air quality while also reducing the adverse risks and impacts associated with climate change.

RECENT TRENDS IN GREENHOUSE GAS EMISSIONS AND CLIMATE

EPA, in collaboration with other government agencies, tracks both changes in climate and changes in GHG emissions. Figure 34 shows the trends in domestic GHG emissions over time. Total U.S. emissions increased 17 percent from 1990 to 2007. Primary contributors to this increase include an increased consumption of fossil fuels to generate electricity and a significant decrease (14 percent) in hydropower generation (electric power generated using water power) used to meet this demand.

A number of EPA scientists participate on the Intergovernmental Panel on Climate Change (IPCC), an international scientific body that provides information about the causes of climate change and its potential effects on the environment. In a series of comprehensive reports completed in 2007, the IPCC concluded that "warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level." Global mean surface temperatures have been rising and the IPCC reported that since the mid 20th century, most of the observed increase is very likely due to the observed increase in human-made GHG concentrations.

CLIMATE'S EFFECTS ON AIR QUALITY

Due to climate change, the IPCC predicted "declining air quality in cities." In summarizing the impact of climate change on ozone and particle pollution, the IPCC concluded that "future climate change may cause significant air quality degradation by changing the dispersion rate of pollutants; the chemical environment for ozone and particle pollution generation; and the strength of emissions from the biosphere, fires, and dust." Though a great deal of uncertainty remains regarding the expected future impacts of climate change on air quality, recent research suggests that such effects may be very significant, particularly on a local or regional scale.

Ground-level ozone is influenced by shifts in the weather, such as the periodic occurrence of heat waves. Changes in the weather that might result from climate change, such as warmer temperatures and more or less frequent episodes of stagnant air, therefore also have the potential to affect ground-level ozone. The potential impact of climate change on particle pollution is less well understood, but recent studies have begun to look at this relationship.

A 2009 report by EPA (EPA Assessment, 2009) investigates the potential impacts of climate change on both ozone and particle pollution (while holding emissions constant). With regard to ozone, the

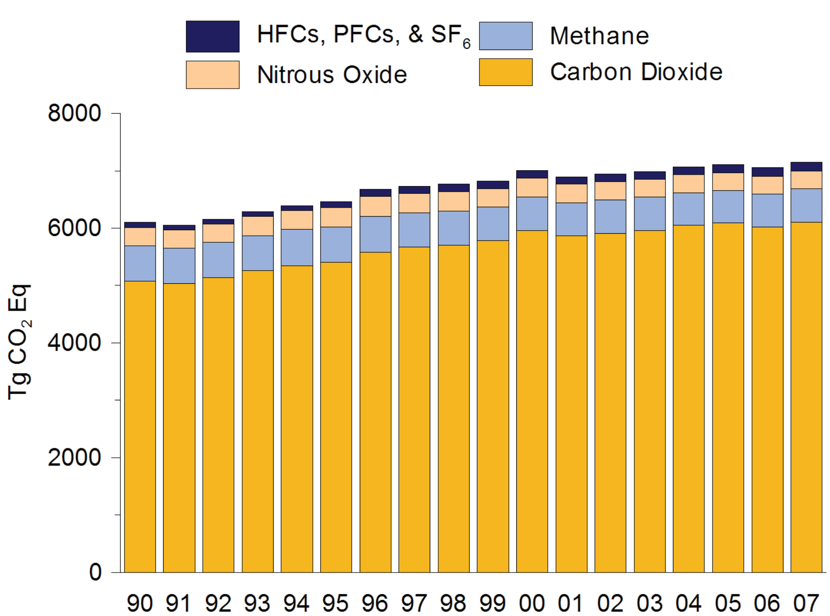

Figure 34. Domestic greenhouse gas emissions in teragrams of carbon dioxide equivalents (Tg CO_2 eq), 1990-2007. (Source: http://epa.gov/climatechange/emissions/usinventoryreport.html)

Notes: A teragram is equal to 1 million metric tons. Emissions in the figure include fluorocarbons (HFCs, PFCs) and sulfur hexafluoride (SF_6).

assessment indicates climate change (between the present and 2050) has the potential to:

- Produce significant increases in summertime average ground-level ozone concentrations in many regions by 2 to 8 parts per billion, as shown in Figure 35
- Exacerbate peak ozone concentrations on days where weather is already conducive to high ozone concentrations
- Lengthen the ozone season
- Increase emissions of ozone precursors from natural sources

In general, while this type of modeling study cannot precisely predict what the future will hold, it does demonstrate the potential for global climate change to exacerbate ground-level ozone pollution across the U.S. The findings of this study indicate that, where climate change-induced increases in ground-level ozone do occur, damaging effects on ecosystems, agriculture, and health may be pronounced, due to increases in average pollutant concentrations and the frequency of extreme pollution events. Further studies are needed to understand how changes in future emissions patterns will affect climate and air quality interactions.

For particle pollution, the results from EPA's assessment are less definitive. The report indicates that future climate conditions may be associated with a range of impacts—both increases and decreases—in particle concentrations in different regions and may also affect different components of particle pollution differently. Specifically, the study's limited findings show:

- Globally, particle pollution generally decreases as a result of simulated climate change (with manmade emissions held constant), due to increased atmospheric humidity and/or increased precipitation
- Regionally, simulated climate change produces both increases and decreases in particle pollution (on the order of a few percent) in 2050, depending on the region of the U.S., with the largest increases in the Midwest and Northeast
- The responses of the individual components of particle pollution (e.g., sulfate, nitrate, ammonium, BC, organic carbon) to climate change are highly variable, depending on the properties and transport characteristics of each component
- Particle pollution is expected to be influenced by meteorological factors such as precipitation, clouds, and temperature, all of which are affected by climate change

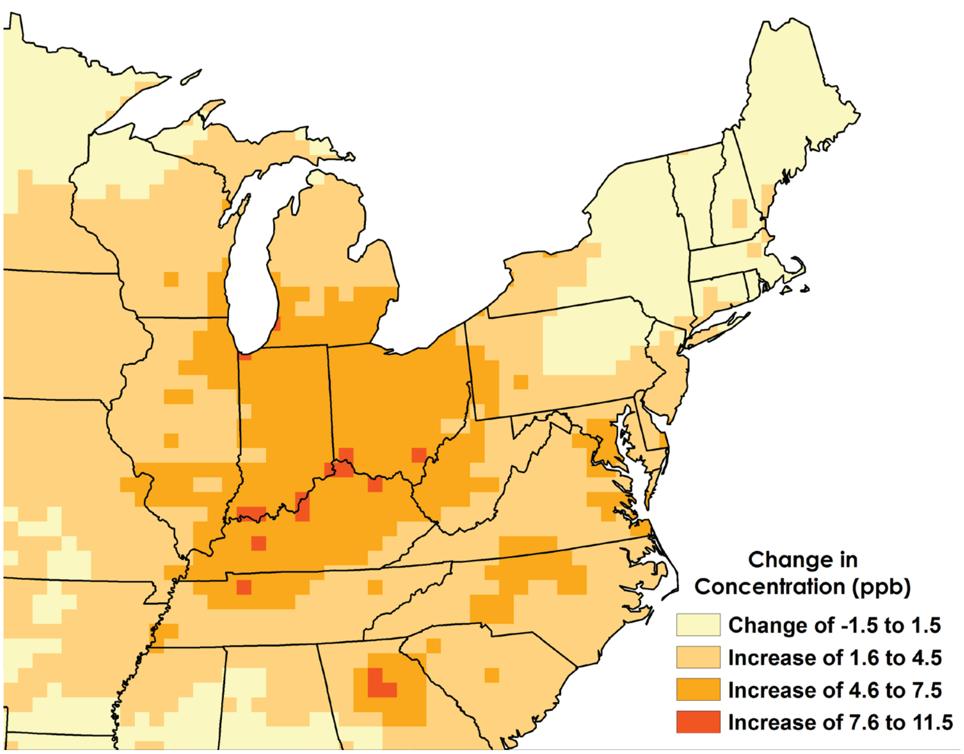

Figure 35. Increases in average summertime ozone concentrations in the eastern U.S., due to climate change, are predicted for 2050. (Source: Figure 33 from EPA Assessment, 2009. 2050s-minus-present differences in simulated summer mean maximum daily average 8-hour ozone concentrations; reproduced from Figure 2 in Hogrefe et al., 2004.)

IMPACTS OF SHORT-LIVED POLLUTANTS ON THE ARCTIC CLIMATE

Arctic temperatures have increased at almost twice the global average rate over the past 100 years (IPCC, 2007). Warming in the Arctic has been accompanied by an earlier onset of spring melt. During the 2007 melt season, Arctic sea ice dropped to the lowest levels observed since satellite measurements began in 1979, resulting in the first recorded complete opening of the Northwest Passage. As sea ice shrinks, less sunlight is reflected from the Earth's surface, leading to further warming.

Reducing emissions of carbon dioxide (CO_2) globally is essential to long-term global (and Arctic) climate stabilization, but will not significantly change the rate of warming in the Arctic over the next few decades due to the long lifetime of CO_2 in the atmosphere. However, reducing emissions of short-lived pollutants may impact Arctic climate on a more immediate timescale. Several short-lived pollutants, including black carbon (BC) and ozone, are contributing to the accelerated rates of warming.

BC emissions lead to climate warming by absorbing incoming and reflected sunlight in the atmosphere. BC deposited on ice increases the rate of warming and melting of the ice. Due to these effects, and because BC in the atmosphere causes more warming when it is present over reflective surfaces such as ice, BC has impacts in the Arctic and over other snow and ice covered areas. Ground-level ozone has also been shown to play an important role in seasonal Arctic warming trends (Shindell et al., 2006). Warming due to ground-level ozone is at a maximum during spring when transport of ozone is efficient, sunlight is abundant, and substantial ozone precursors have built up over the winter.

This image compares the average sea ice extent from September 2007 to September 2005; the red line indicates the long-term median from 1979 to 2000. (Data source: Courtesy of the National Snow and Ice Data Center, Boulder, CO; http://nsidc.org/news/press/2007_seaiceminimum/20071001_pressrelease.html)